FY03 **INSTRUCTOR'S LESSON PLAN**

COURSE: National Electrical Code **COURSE CONTROL NO: 078**

SUBJECT: Motors Lighting & Equipment **INSTRUCTOR: Mark McNamara**

SECTION: **4 (part I)**

TIME PERIOD (TOTAL): 4 hrs **DEVELOPER: Mark McNamara**

TYPE of LESSON: Lecture

TRAINING AIDS: Powerpoint presentation File # Section 4 Part1 workbook Aug03.ppt, Proxima, laptop computer with remote mouse, screen; pointer. Note instructor uses Section 4 Part 1 show Aug03.ppt file for the presentation, since it has the fly-ins.

OBJECTIVES:

At the conclusion of this session, with the use of course materials, students will be able to accurately:

1. Identify the various types of equipment or installations that allows flexible cords and cables to be used.
2. Determine if a panel board is a lighting and appliance panel board or a power panel board.
3. Determine when end-to-end fluorescent lighting fixtures can be used as a raceway for circuit conductors.
4. Identify an appliance.
5. Identify the markings on motor nameplates.
6. Identify the various tables used for sizing motor protection.

This part covers Chapter 4 in the National Electric Code (NEC) with emphasis on the following Articles:
Article 400 Flexible Cords and Cables
Article 404 Switches
Article 406 Receptacles, Cord Connectors, and Attachment Plugs
Article 408 Switchboards and Panelboards
Article 410 Luminaires (Lighting Fixtures), Lampholders, Lamps,
Article 422 Appliances
Article 424 Fixed Electric Space-Heating Equipment
Article 430 Motors, Motor Circuits, and Controllers

Only part of Article 430 is covered in Part 1 due to the size of the Article and the importance of the Article.

These are not covered formally during the class, but if someone has a question it is discussed.
Article 402 Fixture Wires.
Article 411 Lighting Systems Operating at 30 Volts or Less
Article 426 Fixed Outdoor Electric Deicing and Snow-Melting Equipment.
Article 427 Fixed Electric Heating Equipment for Pipeline and Vessels.

Test Questions: *Test questions are in file: posttestnec04 Aug03.doc.*
The following test questions pertain to Articles covered in Part 2:

- *Question 6 pertains to Articles 424.*
- *Question 7 pertains to Article 430.*
- *Question 8 pertains to Articles 445 and 450.*
- *Question 9 pertains to Article 450.*
- *Question 10 pertains to Article 430.*

Note that the test questions put an emphasis on material covered in Part 2 of the lecture. That is where considerable importance is placed. The homework questions compliment this by placing emphasis on material covered in Part 1.

6. A disconnect for a fixed electric space heater (without supplementary overcurrent protection devices) must be:

    a. Within sight
    b. Lockable in the closed position
    c. Lockable in the open position
    d. Within sight or lockable in the open position

Answer: d – 424.19(B)(2)(2)

7. A motor disconnect switch does not have to be within sight of its motor where such a location introduces additional or increased hazards to persons or property. This condition requires the disconnecting means to be:

    a. Explosionproof.
    b. Lockable in the open position. **
    c. A fused switch
    d. A circuit breaker

Answer: b – 430.102(B)Exception(a)

8. A separately derived system is a system where:

    a. There *is* a direct electrical connection between the different sources of power.
    b. There *is not* a direct electrical connection between two different sources of

power. **
c. The phase conductors are connected together under all conditions.
d. The system must be mathematically derived.

Answer: b – definition 100

9. Where the overcurrent protective device is provided on the primary only for a transformer rated 600 volts or less, the protective device shall be set to open at 125% of rated primary current if:

a. The transformer primary *is less than* 2 amperes.
b. The transformer primary *is less than* 9 amperes.
c. The transformer primary *is greater than* 9 amperes. **
d. The transformer secondary *is greater than* 9 amperes.

Answer: c – Table 450.3(B)

10. Motor controllers with a straight voltage rating of 480 volts can be used on voltage systems rated:

a. 208 volts only.
b. 480 volts only.
c. 480 volts and 480/277 volts. **
d. 600 volts.

Answer: c – 430.83(E)

Homework Questions: Homework questions are in file: section4 homework 02.doc

The following homework questions pertain to Articles covered in Part 1:

- Question 1 pertains to Article 400
- Question 2 pertains to Article 406
- Question 3 pertains to Article 408
- Question 5 pertains to Article 422
- Question 6 pertains to Articles 422, 424, 430 and 440 (Part 2).
-

1. Flexible cords and cables shall be used for:
   a. wiring of luminaires
   b. connection of portable lamps and appliances
   c. elevator cables
   d. All of the above.

Answer: d – 400.7

2. A snap switch shall be considered effectively grounded if the following is met:
   a. An equipment grounding conductor is connected to an equipment grounding termination of the snap switch.
   b. The switch is mounted with metal screws to a metal box

c. The snap switch is installed per a or b above
d. None of the above.

Answer: c – a meets 404.9(B)(1) and b meets 404.9(B)(2)

3. 15 or 20 amp, 125V or 250V Receptacles installed in a wet location:
   a. If attended, the receptacle needs to have the enclosure, which is weatherproof, only when plug is removed.
   b. Shall be a normal receptacle used indoors.
   c. Shall be black.
   d. Shall have an enclosure, which is weatherproof, whether or not the plug is inserted or not.

Answer: d – 406.8(B)(1)

5. Luminaires shall not be used as a raceway for circuit conductors unless they meet the following condition(s):
   a. The luminaire is listed and marked for use as a raceway.
   b. The luminaires are designed for end-to-end assembly to form a continuous assembly.
   c. The luminaires are connected together by recognized wiring methods.
   d. All of the above.

Answer: d – a meets 410.31; b meets 410.32; c meets 410.32

6. Permanently connected appliances over 300 VA or 1/8 hp shall allow branch-circuit circuit breakers to serve as the disconnect when:
   a. The breaker is within sight of the appliance
   b. The breaker is capable of being locked in the open position
   c. The breaker is installed per a or b above
   d. None of the above

Answer: c – 422.31(B)

INSTRUCTOR REFERENCES: NFPA 70 (National Electric Code), Soares Grounding by IAEI.

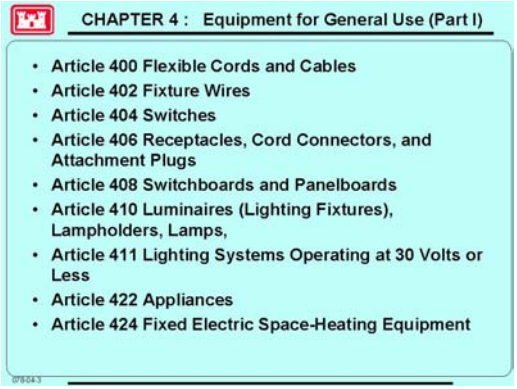
STUDENT REFERENCES AND HOMEWORK: Student workbooks

PROPONENT APPROVAL: _____ DATE:_____

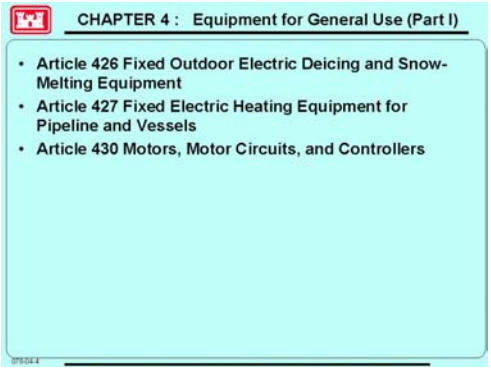
CEHR-P APPROVAL: _____ DATE:_____

TIME	AID CUES	LESSON OUTLINE
10 min	**Introduction** Powerpoint presentation	Introduction and tie in. Introduce subject: provide its importance and how it ties in to other topics, introduce objectives, and provide brief overview of what will be covered on this topic.
	Lecture Powerpoint Presentation	Discuss material using Powerpoint presentation.
10 min	**Summary**	Summarize important points and relationships. Answer questions. Review objectives.

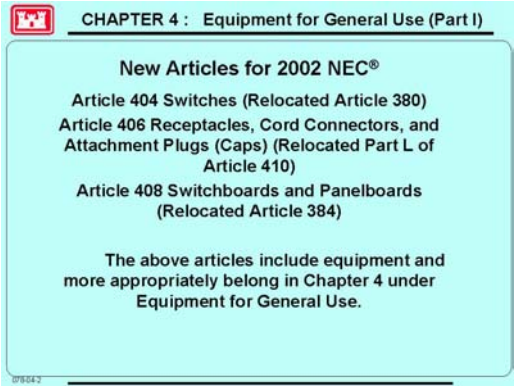
CHAPTER 4: Motors, Lighting and Equipment (Part I)
4-hours. (Typically Monday & Wednesday morning). Breaks are typically 10 minutes long and done every hour. Total 30-40 minutes minimum break time. Avg is 2.5 minutes a slide.



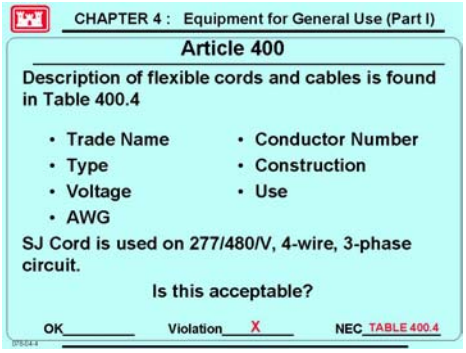
Slide 078-04-1:
Partial List of Articles in Chapter 4 of the NEC. These items will be covered in Part I.



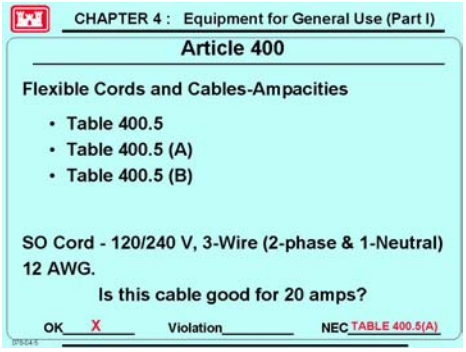
Slide 078-04-2:
Partial List of the Chapter 4 Articles. These items will be covered in Part 1. Article 430 will be completed in Part II.



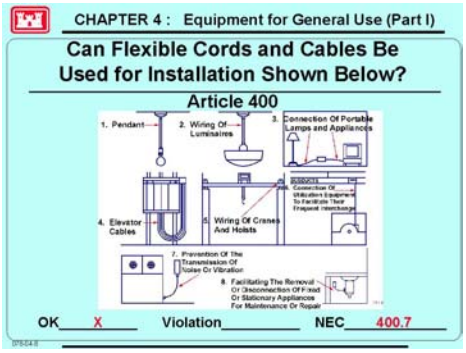
Slide 078-04-3:
Discussion on the new and relocated code articles.



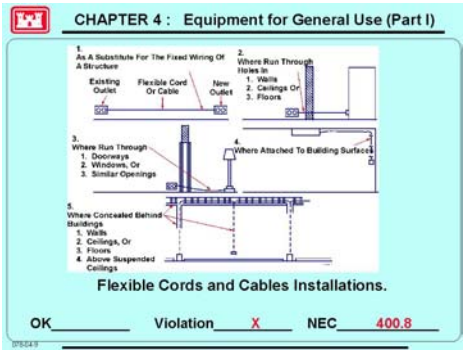
Slide 078-04-4:
Flexible Cords and Cables are described in **Table 440.4**. Read section 400.4. Table covers several parameters regarding the cord or cable. Example of improper use. New in 2002 was the addition of voltage. Voltage markings on flexible cords and cables are optional. The addition of voltage to the table allows the user to find the voltage rating when not marked on the cable. The example shows that voltage needs to be taken into account when using cord and cables. SJ cord is rated 300 Volts.



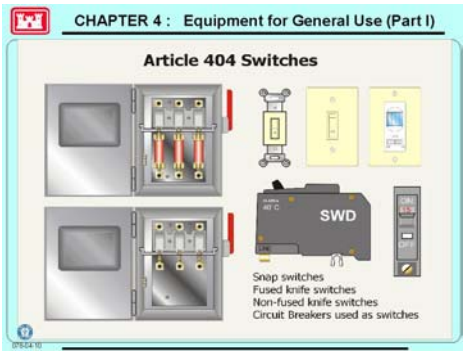
Slide 078-04-5:
Article 400 – Cords and Cables ampacity. **Table 400.5(A)**. Read Section 400.5. The article discusses the current carrying capacity requirements for cables and cords. Depends on number of current carrying conductors and the cable construction type in order to determine. Note 4-wire is 3 phase, neutral.



Slide 078-04-6:
Article 400 – **400.7 Uses Permitted.**
Item 2 note luminaire instead of fixture was a 2002 change.
Item 6 in 2002 the word stationary was replaced with utilization. This was to make it understood that the item didn't have to be permanently fixed.
Other items not covered shown on the slide, but are permitted:
Data processing cables as permitted by 645.5, Connection of moving parts (good example is a hangar door) and Temporary wiring as permitted in Section s 5.27.4(B) and 527.4(C). Temporary construction is limited to what is given in 527.3.

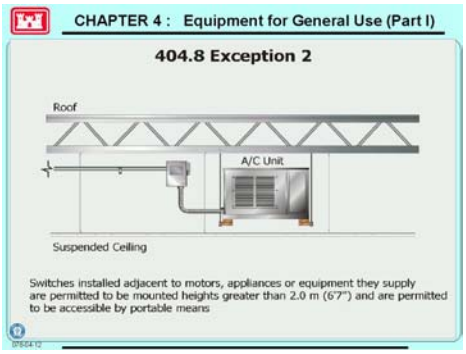


Slide 078-04-7:
Article 400 – **Installations are not permitted - 400.8**
Item 5 – 2002 added above suspended ceilings.
Item 6 not shown. Installations are not permitted in raceways except as otherwise permitted by the Code.
Mention Article 402 before next slide.

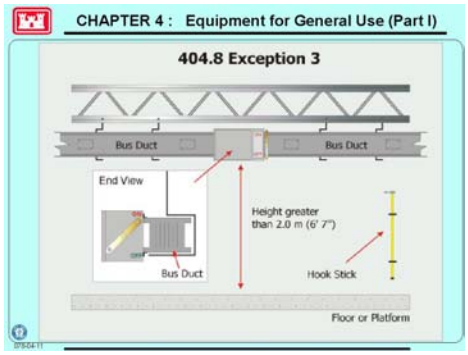


Slide 078-04-8:
Article 404 covers all switches, switching devices and circuit breakers where used as switches. Circuit breakers used as switches are to be marked for that use. See Section 240.83D.

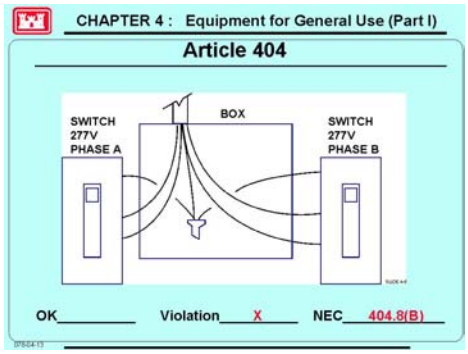
Slide 078-04-9:
Accessibility and Grouping.



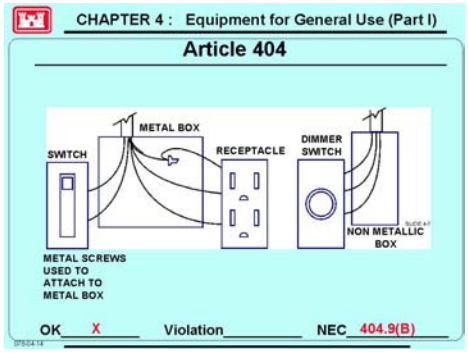
Slide 078-04-10:
*******Note that there has been a change to add the wording circuit breakers in the exception. This slide is not correct. Wording shown is wording from 1999 Code.**



Slide 078-04-11:



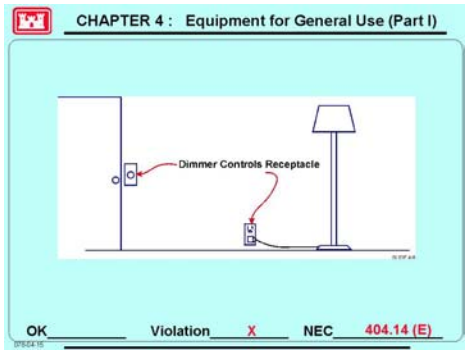
Slide 078-04-12:
Article 404 – Switches. **404.8(B) Voltage Between Adjacent Devices.**
New Article in 2002.
The example shows two switches which have 277V on different phases. The box has no divider, therefore, there is 480V between the phases. This is in violation of the code that limits it to max of 300V. *****need to correct slide with missing gnd



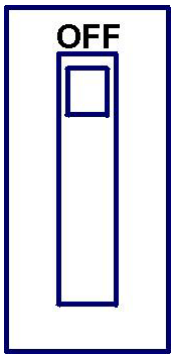
Slide 078-04-13:
Article 404 – **404.9(B) Grounding of Snap-Switches.**
This slides talks about the proper grounding of switches and receptacles.

(1) switch is mounted with metal screws to a metal box.
(2) An equipment grounding conductor or equipment bonding jumper is connected to an equipment grounding termination

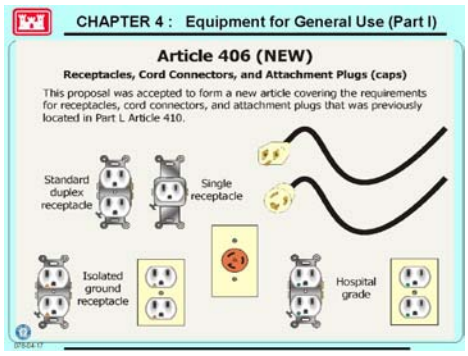
on the snap switch. The wording "and similar control switches" was added in 2002 to make it clear that timers and fan control switches must be effectively grounded. *****need to correct slide with missing gnd
250.126 talks about identification of wiring device terminals.



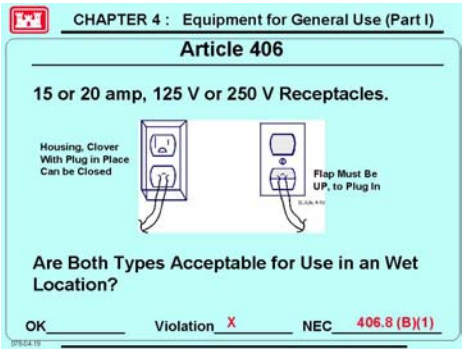
Slide 078-04-14:
Article 404 - **404.14(E) Dimmer Switches**
Illustration is new for the 2002 NEC. This requirement is contained in the listing and installation instructions for dimmers. This makes it clear by inserting in the Code. Dimmer switches cannot be used to control receptacles.



Slide 078-04-15:
Article 404 – **404.15(B) Off Indication**
New in 2002 NEC. This was to make it clear that devices such as electronic occupancy sensors that do not disconnect the conductor are not to be marked OFF. These sensors can have a small current flow of 0.5 mA even when in the expected OFF position. This is enough to surprise an individual

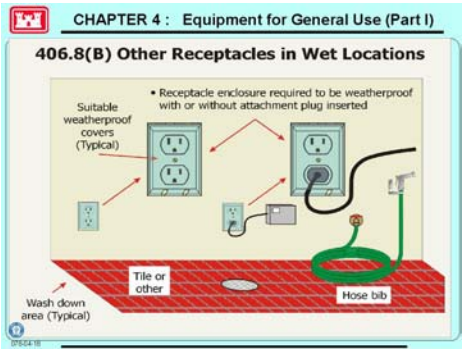


Slide 078-04-16:



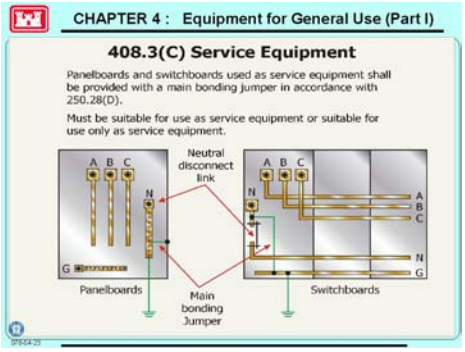
Slide 078-04-17:
Article 406 – Receptacles, cord connectors, and attachment plugs (caps) – 406.8(B)(1)
New in 2002 NEC. Most of the information used to be found in Article 410 until it was moved into this Article.
The intent of this is to ensure that in wet locations, the receptacle is in an enclosure which is rated for a wet location even if there is a receptacle in use.
Take opportunity to discuss difference between damp and wet locations per Article 100.

Slide 078-04-18:
Picture of a suitable type of cover.

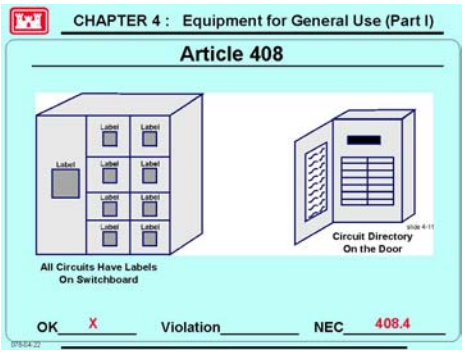


Slide 078-04-19:
This slide is on other receptacles besides 120V. Slide doesn't show the receptacles correctly for "Other Receptacles" since the type is clearly 120V

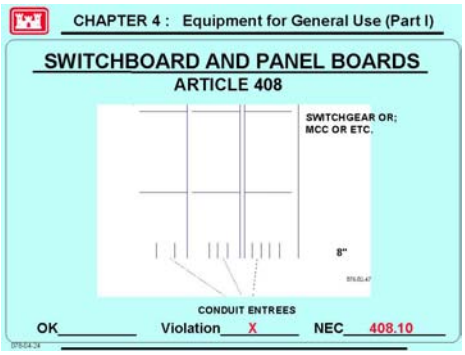
Slide 078-04-20:



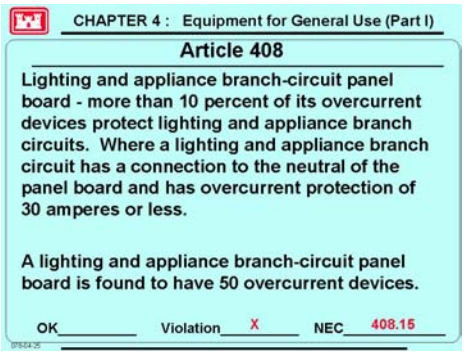
Slide 078-04-21:
Discuss 408.3(C). Also use this slide to discuss 408.3(E) on phase arrangement in equipment.



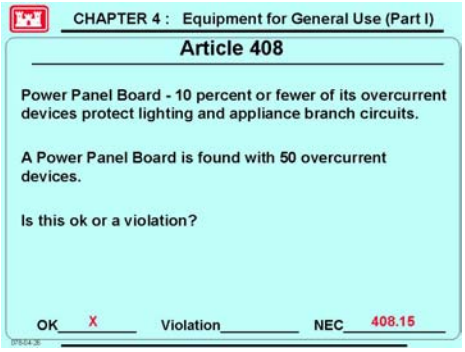
Slide 078-04-22:
Article 408 – Switchboards and Panelboards – 408.4 Circuit Directory
New in 2002 NEC. Slide covers the code requirement that panelboards and switchboards are to have labels identifying the purpose of the circuit. The addition of switchboards is new in 2002.



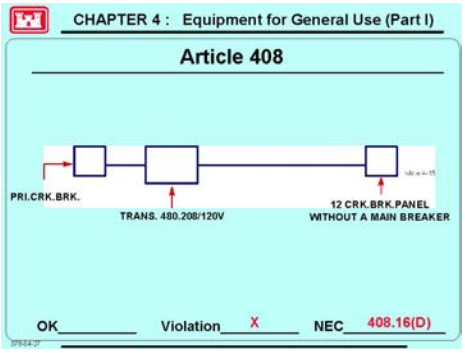
Slide 078-04-23:
Article 408 – **408.10 Clearance for conductors entering bus enclosures**.
The conduit entries can only be a maximum of 3 inches.



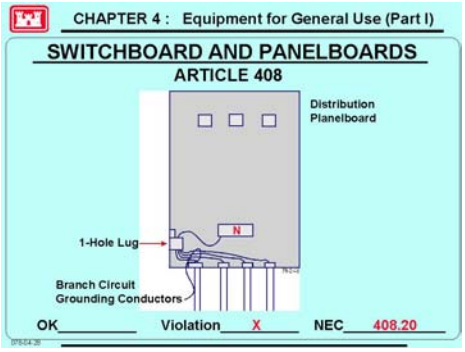
Slide 078-04-24:
Article 408 – **408.14(A) Classification & 408.15 Number of Overcurrent devices in one panelboard**. Start by covering 408.14.
Slide covers what a lighting and appliance branch-circuit panelboard is and the number of poles allowed in the panelboard. Not more than 42 overcurrent devices.



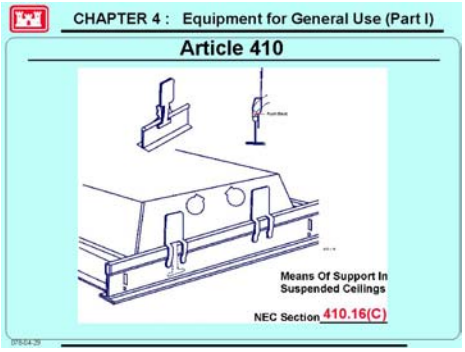
Slide 078-04-25:
Article 408 – **408.14(B) & 408.15 Number of Overcurrent devices in one panelboard**.
Slide covers what a power panelboard is and the number of poles allowed in the panelboard.
Some manufactures do have panelboards with more than 42 poles.



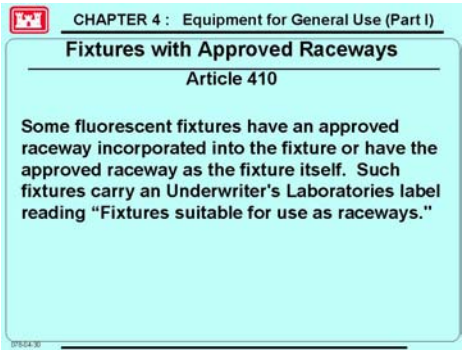
Slide 078-04-26:
Article 408 – **408.16(D) Overcurrent protection for panelboard when supplied through a transformer.**
Example is a violation. All panelboards supplied by a three-phase, four-wire transformers must have overcurrent protection on the secondary side of the transformer. The exception in 240.21(C)(1) is for single phase transformers and delta/delta transformers. (A) Each L&A needs a main breaker; (B) Power – within or at any point on the supply side of the panelboard; (C) Snap switch use.



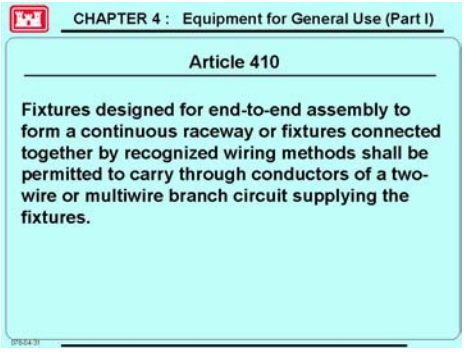
Slide 078-04-27:
Article 408 – **408.20 Grounding of Panelboards**
Slide shows that the grounding conductor lug is not to be connected to the neutral bar, except under special conditions and that the conductor lug needs to be a bar. "a terminal bar for the grounidng conductors shall be secured inside the cabinet.



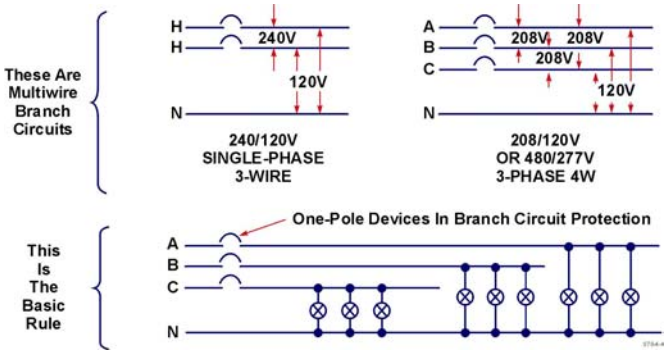
Slide 078-04-28:
Article 410 – Luminaires (Lighting Fixtures), Lampholders, and Lamps
– 410.16(C) Support in Suspended Ceilings.
Slide is a discussion on the support requirements for a recessed light fixture. The fixture must be securely fastened to ceiling framing members. Use of term luminaires is new for 2002.



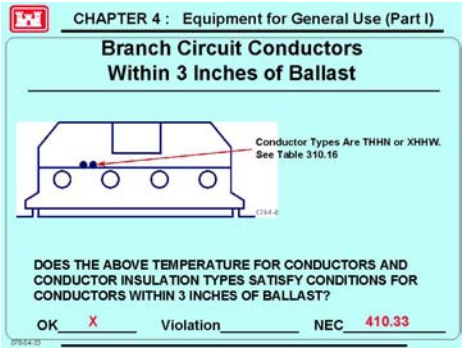
Slide 078-04-29:
Article 410 - **410.31 Luminaires has raceways** (and 410.32 for those connected together which is on the next slide.)
Read slide and discuss.



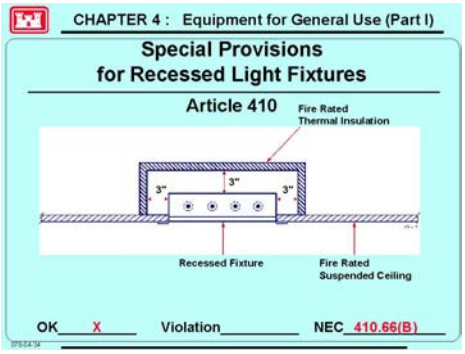
Slide 078-04-30:
Article 410 - **410.32 Wiring supplying luminaires connected together.**
Need to read and also go to the definitions on branch-circuit, multiwire, which is found in the front end definitions.



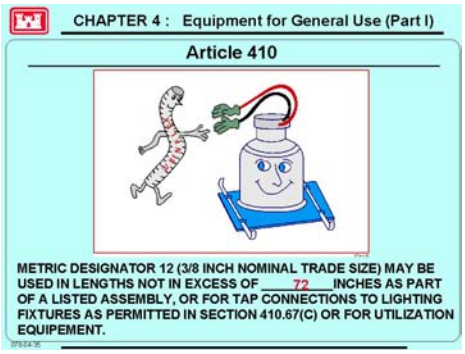
Slide 078-04-31:
Article 410, 210.4 and definitions. Just a quick visual on multiwire circuits. This is covered by Johnny also.



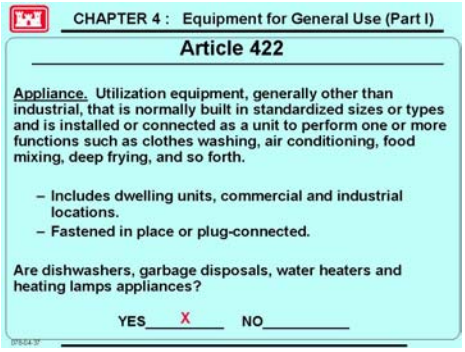
Slide 078-04-32:
Article 410 – **410.33 Branch circuit conductors and ballasts.**
Discussion on wire type used in the luminaire. Must have a certain temperature rating. If within 3 inches of a ballast, need 90 degree C wire unless specifically listed. Table 310.16 indicates THHN can as 90 and XHHW is 90.



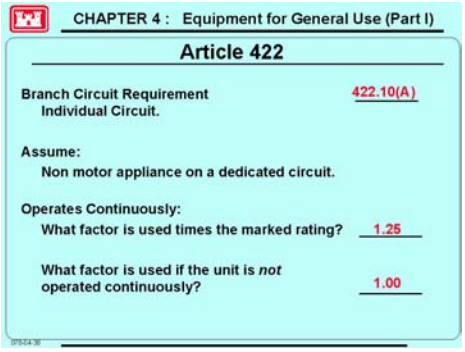
Slide 078-04-33:
Article 410 – **410.66(B) Clearance and installation.**
Discussion on recessed fixture in a fire rated ceiling. Note the ceiling is fire rated then 300.21 spread of fire or products of combustion –requires the fire rated box when in a fire rated ceiling and fire stopping.



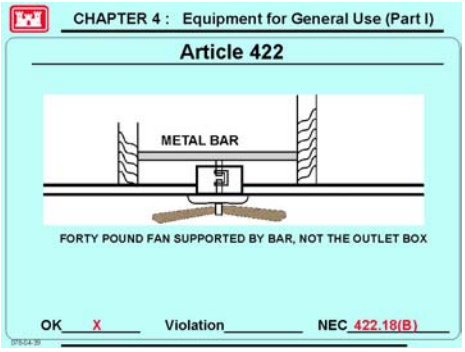
Slide 078-04-34:
Article 410 – **410.67(C) Wiring Tap Conductors.**
Discussion on use of flex and the length. May have to see 348.10 uses of flexible metal conduit (FMC) in order to complete the slide. Also, 250.118(6) discusses use of this type of conduit and proper grounding – terminated in fittings listed for grounding, overcurrent device is a maximum of 20 amperes, length is max of 72 inches, and the conduit is not installed for flexibility.



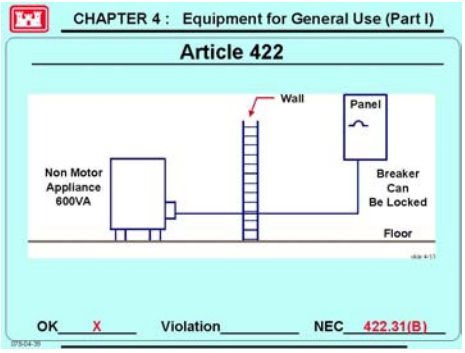
Slide 078-04-35:
Article 422 Appliances.
Cover the meaning of an appliance. Definition is found in Article 100.



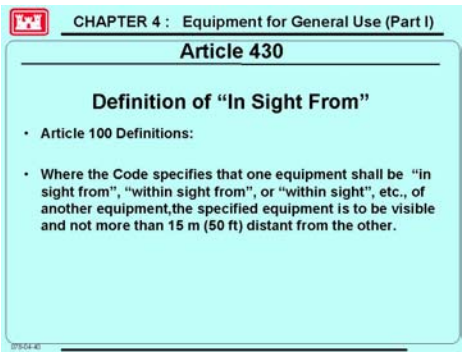
Slide 078-04-36:
Article 422 – **422.10(A) Installation Branch Circuit Rating - Individual Circuits**
Sizing of an individual branch circuit for a nonmotor appliance under two conditions. Definition of continuous is found in Article 100 and is defined as where the item is expected to operate at for 3 hours or more.



Slide 078-04-37:
Article 422 – **422.18(B) Support of Ceiling Fans**
Ceiling fan support. 314.23 Supports of boxes.

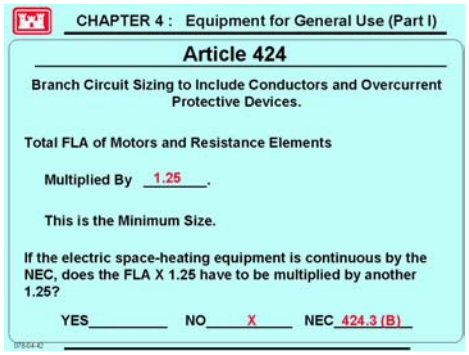


Slide 078-04-38:
Article 422 – **422.31(B) Disconnection of permanently connected appliances over 300 VA.**
Location of disconnecting means for a non-motor appliance. Must be within sight or lockable in the open position.

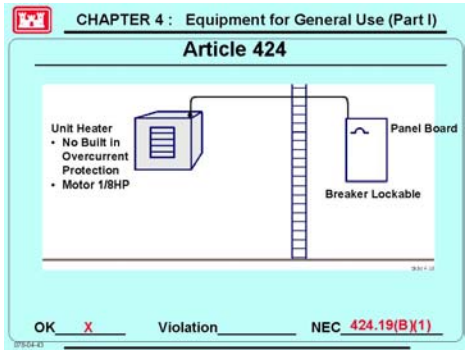


Slide 078-04-39:
Definition is taken from Article 100 in definitions.

Slide 078-04-40:
Article 422 – **422.60 Nameplate Marking.**
Discussion on nameplate requirements for appliances.
Need identifying name; rating in volts & amps or rating in volts & watts. Sometimes frequency is required is a special frequency is used.



Slide 078-04-41:
Article 424 Fixed Electric Space-Heating Equipment
- 424.3(B) Branch Circuit Sizing
Discussion on sizing conductors and breaker for fixed electric space-heating equipment.



Slide 078-04-42:
Article 424 – **424.19(B)(1) Disconnecting means**
Example of disconnecting means for this type of equipment

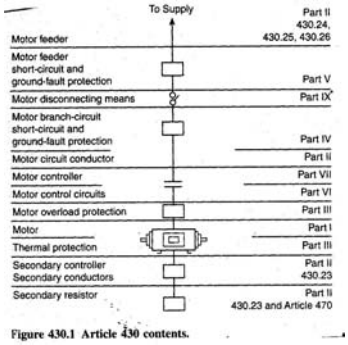
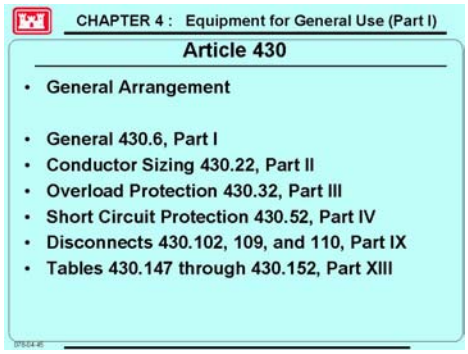
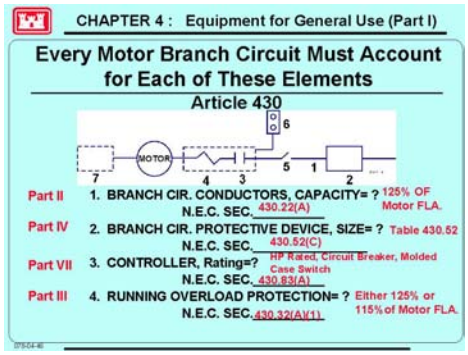


Figure 430.1 Article 430 contents.

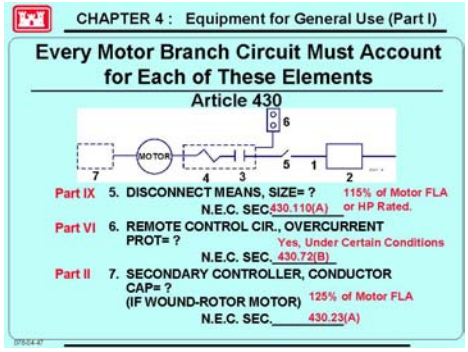
Slide 078-04-43:
Article 430 Motors, Motor Circuits, and Controllers
- Figure 430.1 Article 430 Contents
Slide shows the basic layout of this section.



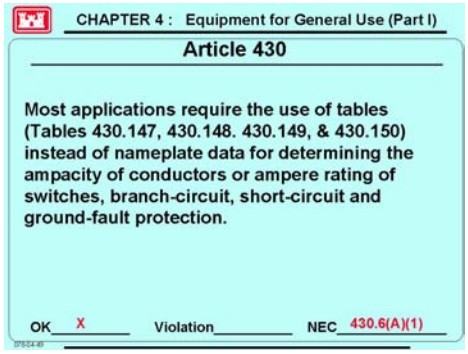
Slide 078-04-44:



Slide 078-04-45
Article 430
Slide shows the basic structure of an individual motor circuit and the various locations to find how to size and/or calculate various elements. Ties in with the previous slide. Just provide the information. This is more to see where to start looking. I didn't give them 3. in previous slide. Part II – 290; Part IV – 295; VII – 301; III – 292.

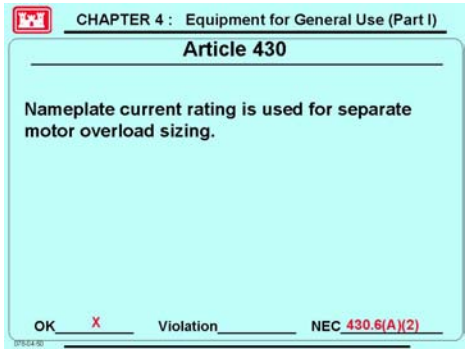


Slide 078-04-46
Part IX – 304; Part VI – 299; Part II – 290

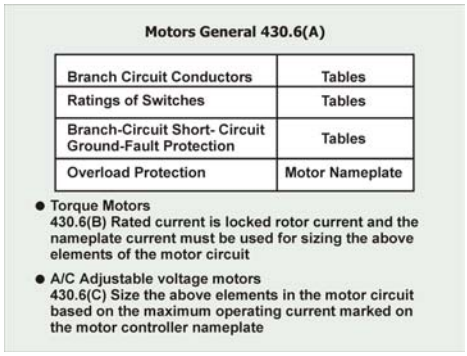


Slide 078-04-47:
Article 430 – Part I - **430.6(A)(1) Ampacity requirements for general motor applications Makes it clear that despite nameplate information, most motor calculations will**

require the use of Tables in the code to determine the branch-circuit short-circuit protection, conductor and switches.

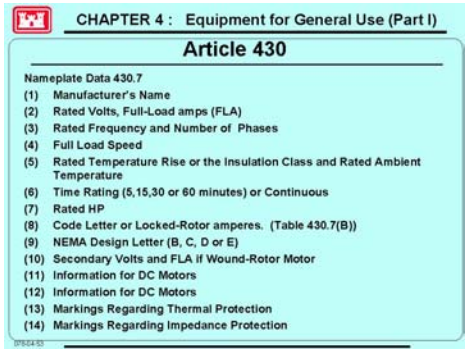


Slide 078-04-48:
Article 430 – Part I - **430.6(A)(2) Ampacity requirements for overload sizing**
Makes it clear the nameplate data is to be used for the overload sizing.



Slide 078-04-49:
Just another slide stating it again.
*****Not sure this one is needed

Slide 078-04-50:
Article 430 – **430.7 Markings on motors.**
Picture of a motor nameplate. Paragraph 430.7 indicates the type of information required to be on a nameplate.



Slide 078-04-51:
Article 430 – **430.7 Markings on motors.**
Discussion on the meaning of the nameplate items.

Nameplate Data
The National Electrical Manufacturer's Association (NEMA) specifies that every motor

nameplate must show these specific items: Manufacturer's Name; Rated volts and full load amps; Rated frequency & number of phases; Rated full load speed; Rated temperature rise or the insulation system class; Time rating; Rated horsepower; Locked rotor indicating code letter; Service Factor; Efficiency; Frame Size; and Design Code. (This is items 1, 2, 3, 4, 5, 6, 7, 8, 9 with service factor, efficiency, and frame size.)
Additional information will normally appear on most nameplates.

(1) Manufactures Name is self explanatory.

(2) Rated Volts And Full Load Amps. Motors will operate at a variety of line voltages, the most common being 230 and 460. These motors will operate according to NEMA limits at rated voltage.

Line voltage will fluctuate due to a variety of factors. Therefore, every motor must be designed to handle these voltage variations. Motors typically can withstand voltage variation of plus or minus 10%, so a 230 Volt motor could operate between approximately 207 to 253 volts. At these extremes, no motor will run at its peak performance, however it will withstand these conditions.

Full load amps is the amperage the motor requires to run at rated load and voltage.

(3) Rated Frequency is the frequency the motor is designed for represented by Hertz (cycles per second). 60 Hertz power is used throughout the United States, Canada, and other parts of the world while 50 Hertz is the standard in the rest of the world. Motors can tolerate a frequency deviation of plus or minus 5%.

(4) RPM (Revolutions Per Minute) of a motor is the speed at which the motor will rotate at rated voltage and frequency during full torque. This "full load" speed will normally vary between 87% and 99% of synchronous speed depending on design. This is known as slip.

Synchronous speed is the theoretical speed of a motor based on the rotating magnetic field. This is determined by the following:

$S = (120 \times F)/P$
S = speed in RPM
F = frequency in hertz
P = # of poles in motor

Or, if you know the number of poles in your motor, you can determine the speed by the following chart:

# of Poles	Synchronous Speed	Actual Speed
2	3600	3450
4	1800	1725

6	1200	1140
8	900	850

(5) Insulation. Insulation is crucial in a motor. Insulation insulates its motor to withstand the greatest temperature that occurs at the hottest point within the motor for as long as the temperature normally exists. This is determined by, the ambient temperature, the heat generated at fully loaded conditions (temperature rise), and the thermal capacity of the motor insulation. These materials are classified as A, B, F, and H. The classes are based on adding the ambient temperature and the operational heat created by the motor. They are shown below.

Class	20,000 Hour Life Temperature
A	105°C
B	130°C
F	155°C
H	180°C

(6) Time rating. Unless otherwise noted motors will be rated for continuous duty. This will be shown as "CONT" on the nameplate.

(7) Horsepower. Horsepower is determined by the output when the motor is loaded to rated torque at rated speed. These are the standard NEMA ratings:

1	30	300	1250
1 ½	40	350	1500
2	50	400	1750
3	60	450	2000
5	75	500	2250
7 ½	100	600	2500
10	125	700	3000
15	150	800	3500
20	200	900	4000
25	250	1000	

When application horsepower requirements fall between two standardized values, the larger size is usually chosen.

The work capacity of a horse was used to define the power of an electric motor. It was determined that a horse could lift 1000 pounds, 33', in one minute. It is the amount of work done in a given amount of time. The formula is:

HP = (Foot #s Per Minute) \ 33,000 -or- HP= (Foot #s per second) \ 550

Torque is the turning or twisting force supplied by a drive to the load, measured in inch pounds or foot-pounds. Torque and horsepower are related as shown:

HP=(Torque X Speed)/Constant

If Torque is given in Ft. Lbs, the constant is 5252

If Torque is given in In. Lbs the constant is 63,025

(8) Locked Rotor Indicating Code Letter. When a motor is started, a large 'inrush' of current is required in order to get a good start. This current is greater than the full load running current. This inrush has been standardized and defined by a series of code letters which group motors based on the amount of inrush in terms of kilovolt amperes. The code letter defines low and high voltage inrush values on dual voltage motors. Code **Table 430.7(B).**

Code	KVA/HP	Approx. Mid-Range Value
A	0.00-3.14	1.6
B	3.15-3.54	3.3
C	3.55-3.99	3.8
D	4.00-4.49	4.3
E	4.50-4.99	4.7
F	5.00-5.59	5.3
G	5.60-6.29	5.9
H	6.30-7.09	6.7
J	7.10-7.99	7.5
K	8.00-8.99	8.5
L	9.00-9.99	9.5
M	10.00-11.99	10.6
N	11.20-12.49	11.8
P	12.50-13.99	13.2
R	14.00-15.99	15.0

Using this chart and the job voltage, you can calculate the across the line starting inrush by using the following:

200 Volts LRA = Code letter value x HP x 2.9
230 Volts LRA = Code letter valve x HP x 2.5
460 Volts LRA = Code letter value x HP x 1.25

(9) NEMA Design Letter. Changes in motor windings and rotor design will alter the performance characteristics of induction motors. To obtain uniformity in application, NEMA has designated specific designs of general purpose motors having specified locked rotor torque, breakdown torque, slip, starting current, or other values. NEMA design letters are A, B, C, and D.

NEMA Design A motors have normal starting torques, but high starting currents. This is useful for applications with brief heavy overloads. Injection molding machines are a good application for this type of motor.

NEMA Design B motors are the most common. They feature normal starting torque combined with a low starting current. These motors have sufficient locked rotor torques to start a wide variety of industrial applications.

NEMA Design C motors have high starting torques with low starting currents. They are designed for starting heavy loads due to their high locked rotor torques and high full load slip.

NEMA Design D motors have high starting torque and low starting current, however they feature high slip. This reduces power peaks in the event that peak power is encountered, motor slip will increase.

DESIGN A, B, C, D - for AC MOTORS
NEMA has standard NEMA motor designs of various torque characteristics to meet the various requirements posed by different application loads. The design "B" is the most common design. (See chart for characteristics of each design.)

NEMA DESIGN	STARTING TORQUE	STARTING CURRENT	BREAK-DOWN TORQUE	FULL LOAD SLIP
A	Normal	High	High	Low
Mach. Tools, Fans				
B	Normal	Normal	Normal	Normal
Same as Design "A"				
C	High	Normal	Low	Normal
Loaded compressor				
Loaded conveyor				
D	Very high	Low	-------	High
High Punch Press				

(10) marking for Thermal protection if integral with motor. TP

(11) Marking for impedance protection if present or not.

Other items which can be on the nameplate:

Motor Service Factor (SF) is a factor that when multiplied by horsepower, gives us the allowable horsepower loading, which may be carried under the conditions specified for the service factor at rated voltage and frequency. This is practical as it gives you some 'fudge' in estimating horsepower needs and actual running horsepower requirements. It also allows for cooler winding temperatures at rated load, protects against intermittent heat rises, and helps to offset low or unbalanced line voltages.

SERVICE FACTOR

When used on a motor nameplate, a number which indicates how much above the nameplate rating a motor can be loaded without causing serious degradation, (i.e., a 1.15 S-F can produce15% greater torque than the 1.0 S-F rating of the same motor).

The drawbacks to running in the service factor area is that it will reduce motor speed and efficiency & increase motor temperature. This in turn effects the overall life span of the motor. It is for this reason that you should not run in the SF range continuously. Service factors were established for operations at rated voltage, frequency, ambient and sea level conditions.

Efficiency. Efficiency is the ratio of the power output divided by the power input. The efficiency is reduced by any form of heat, including friction, stator winding loss, rotor loss, core loss (hysteresis and eddy current), etc.

Frame Size. Motor frame size have been standardized with a uniform frame size numbering system. This system was developed by NEMA and specific frame sizes have been assigned to standard motor ratings based on enclosure, horsepower and speed.

Enclosure Type. Motors are typically supplied in open drip-proof (ODP), totally enclosed fan cooled (TEFC), explosion proof (EXP) are a few of the types.

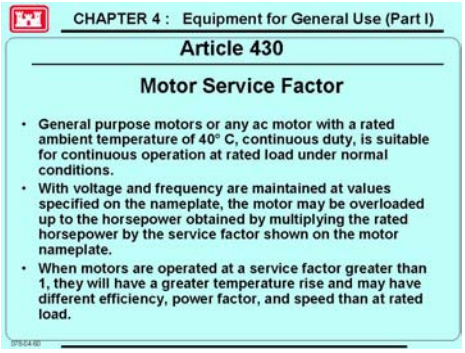
ODG - Open Drip-Proof, Guarded
ODG-FV - Open Drip-Proof, Force Ventilated
ODG-SV - Open Drip-Proof, Separately Ventilated
ODP - Open Drip-Proof
HP - Vertical P-Base, Normal Thrust
LP - Vertical P-base, Medium Thrust, Extended Thrust
Prot. - Protected
TEAO - Totally-Enclosed, Air-Over
TEBC - Totally-Enclosed, Blower-Cooled
TECACA - Totally-Enclosed, Closed Circuit,, Air to Air
TEDC-A/A - Totally-Enclosed, Dual Cooled, Air to Air
TEDC-A/W - Totally-Enclosed, Dual Cooled, Air to Water
TEFC - Totally-Enclosed, Fan-Cooled
TENV - Totally-Enclosed Non-Ventilated
TETC - Totally-Enclosed, Tube Cooled
TEWAC - Totally-Enclosed, Water/Air Cooled
TEXP - Totally-Enclosed, Explosion-Proof
IP-22 - Open Drip-Proof
IP-44 - Totally-Enclosed
IP-54 - Splash Proof
IP-55 - Washdown
WPI - Weather Protected, Type I
WPII - Weather Protected Type II
XE - Premium Efficient

XL - Extra Life
XP - Explosion-Proof
XT - Extra Tough

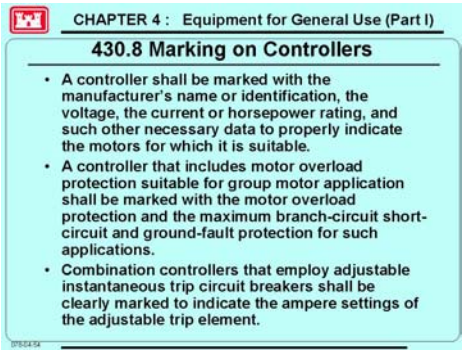
Manufacturer's Identification Numbers. The model, date, & serial number are supplied to aid in identification.

Bearing Part Numbers. The bearing part numbers are included if replacement bearings need to be obtained.

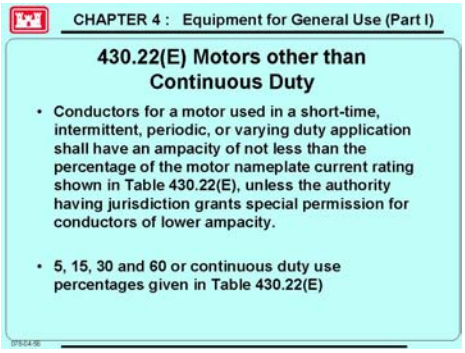
Connection Diagrams. This diagram is to aid a qualified electrician in the wiring of a motor.



Slide 078-04-52:
This is another item which can be on a nameplate is important for overload sizing.



Slide 078-04-53:
self expanatory.



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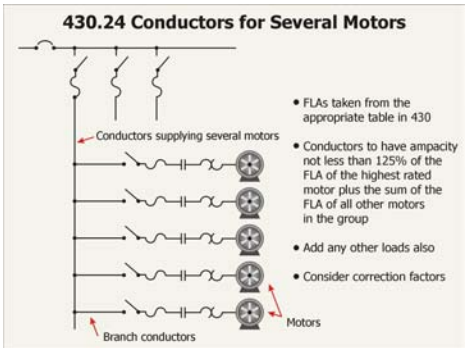
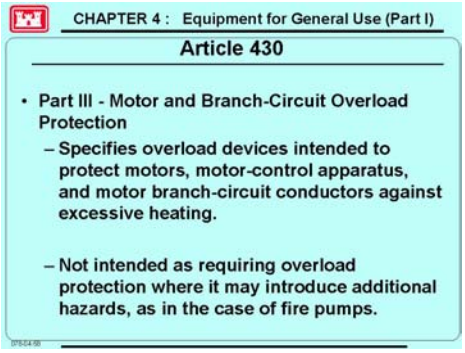
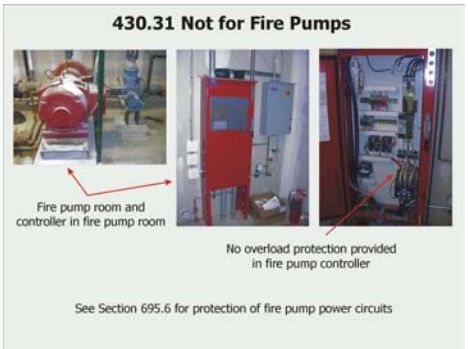


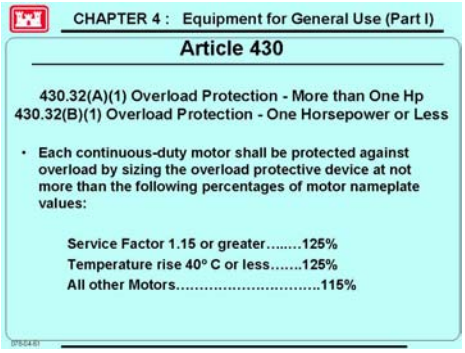
Slide 078-04-55:
Self explanatory.



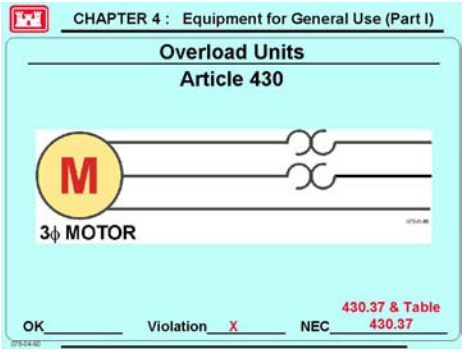
Slide 078-04-56:
Article 430 Part III Motor and branch-circuit overload protection – **430.31 General**
Discussion on the requirements for motor and branch-circuit overload protection.



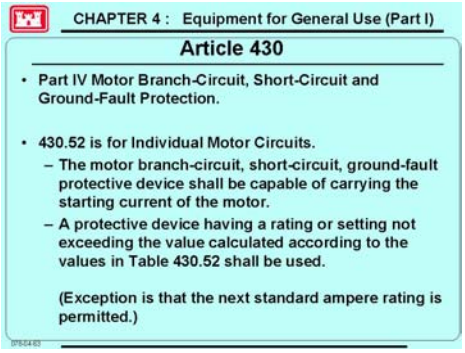
Slide 078-04-57:



Slide 078-04-58:



Slide 078-04-59:
Article 430 – **430.37 Devices other than fuses, Table 430.37 Overload Units.**
Discussion on the motor overload requirement.
If the exception is met then it is not a violation.



Slide 078-04-60:
Article 430 Part IV Motor Branch-Circuit Short Circuit and Ground-Fault Protection
- 430.52 Rating or setting for individual motor circuits.
General discussion on the requirements for Part IV. Note that Table 430.52 used to be Table 430-152, but was relocated in the 2002 code.

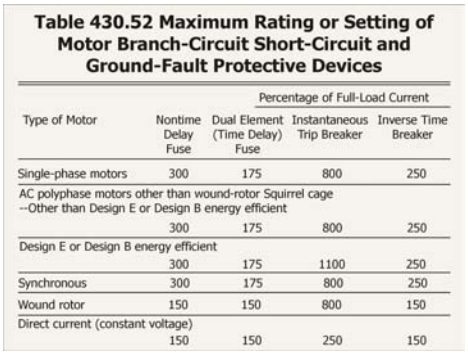
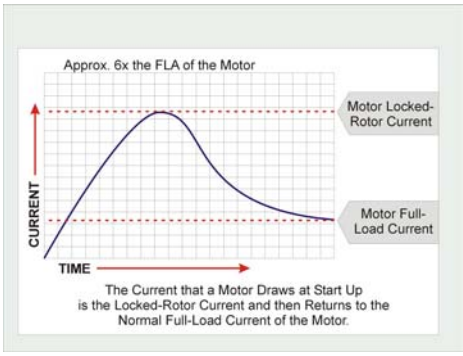


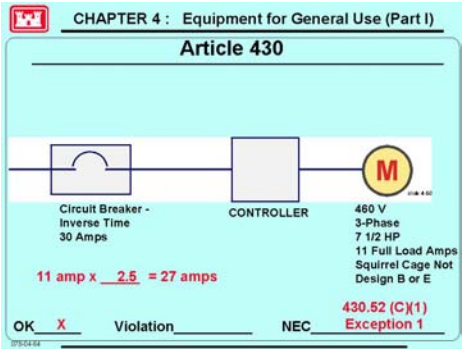
Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

	Percentage of Full-Load Current			
Type of Motor	Nontime Delay Fuse	Dual Element (Time Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
Single-phase motors	300	175	800	250
AC polyphase motors other than wound-rotor Squirrel cage --Other than Design E or Design B energy efficient	300	175	800	250
Design E or Design B energy efficient	300	175	1100	250
Synchronous	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

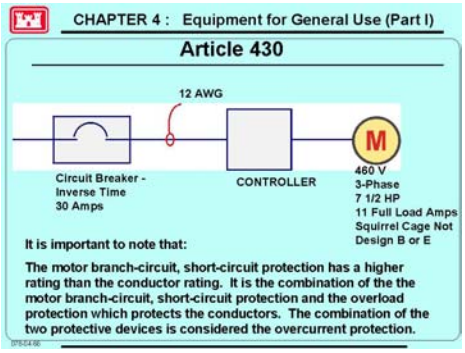
Slide 078-04-61:
shows Table 430.52 without the notes.



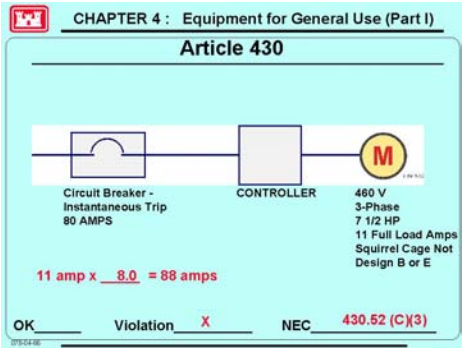
Slide 078-04-62:
the reason for the 250% inverse time breaker or the large 800% instantaneous breaker setting is due to this.



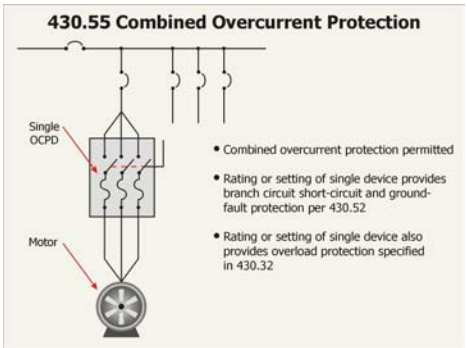
Slide 078-04-63:
Article 430 – **430.52(C)(1) Exception 1 rating or setting with Table.**
Making sure they understand the sizing of the branch-circuit protection. In this example 11 amps x 2.5 = 27 amps. Could pick 25 amp breaker or 30 amp breaker is using exception1



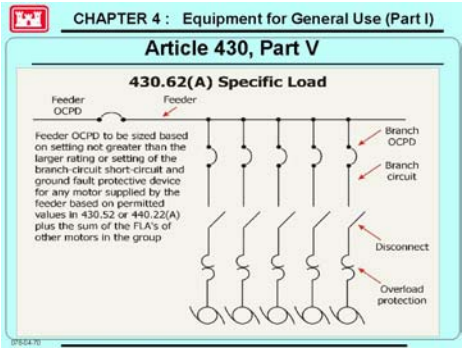
Slide 078-04-64:
Article 430
Making sure they understand that the breaker doesn't have to be sized to protect the conductors. It is the combination of the two – branch circuit short-circuit and overload protection, which protect the conductors.



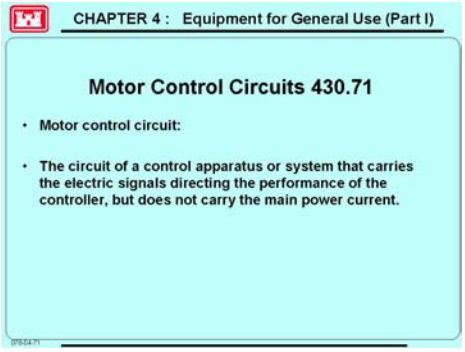
Slide 078-04-65:
Article 430 – **430.52(C)(3) Instantaneous trip circuit breaker TRICK QUESTION**
Example to show that an instantaneous breaker has to be part of a controller assembly such as that used in a motor control center. 11 x 8 = 88 amps. so the rating of 80 amps is okay, could have used 90 amps, but the breaker must be part of a listed combination motor controller



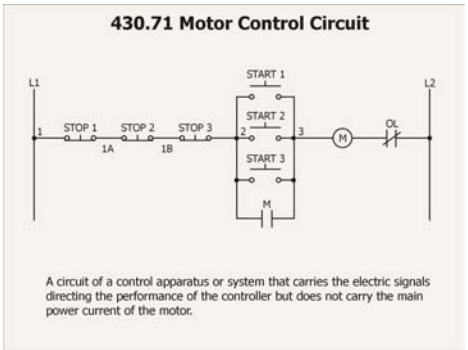
Slide 078-04-66:
this typically will only work for smaller motors.



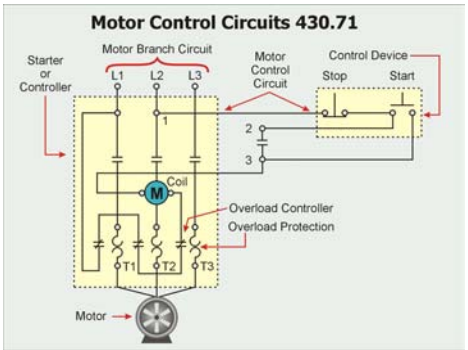
Slide 078-04-67:
this would be found in a motor control center.
430.52 is the table for fuse and circuit breaker sizing
430.24 sizing conductor for several motors: 1.25 x largest plus fla other motors and fla other loads. Important expection 2 allows table to be ignored and go to a higher rating



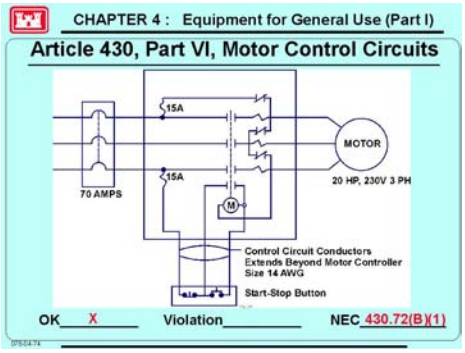
Slide 078-04-68:



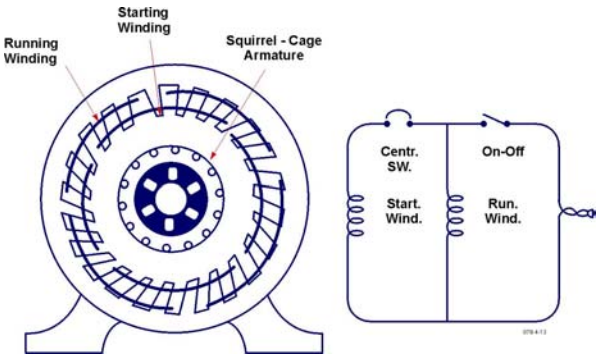
Slide 078-04-69:
this is called a ladder diagram for a control circuit or an elementary diagram.



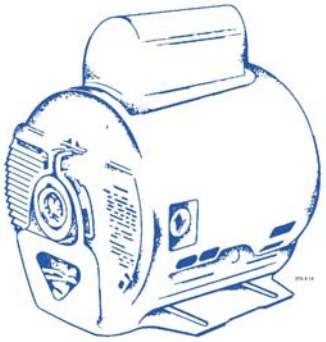
Slide 078-04-70:
this is a wiring diagram.



Slide 078-04-71:
Article 430 Part VI Motor Control Circuits – **430.72(B)(1) Overcurrent Protection & Table 430.72(B)**
Example shows overcurrent protection in each power phase conductor is required. Reason is using 430.72(B)(2), for conductors extending beyound the enclosure it directs to see Table 430.72(B) column C. We have #14 which indicates that the breaker has to be 45 amps or less to work with 14 AWG and since the example shows 70 amps, one had to use Column A in the table which is separate protection. 310.15 which directs to see 240.4(D) which indicates 15 amp circuit breaker for #14 wire.



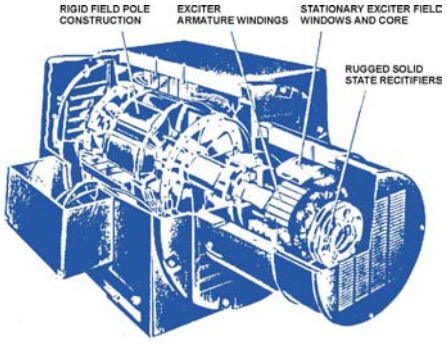
Slide 078-04-72:
Article 430 - **Split-phase Motor.**
Split-phase motor is an induction motor. An induction motor like a squirrel cage motor operates on the same basic principle has a transformer where you have a primary and a secondary winding. A split-phase motor requires an additional winding called a starting winding on the stator. The starting winding has a higher resistance than the running winding. The difference in resistance creates a phase displacement between the two windings. Hence the name split-phase. Displacement is around 18 to 30 degrees in time. Splitting the phases provides enough torque to start the motor. When the rotor starts spinning (turning) and comes up to running speed (around 75%-80% of synchoronus speed), a centrifugal switch placed in the circuit of the starting winding opens up. The motor will then operate on the running winding.



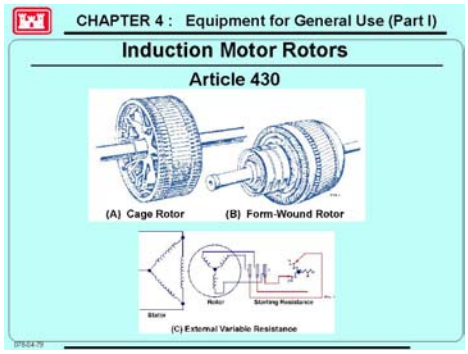
Slide 078-04-73:
Article 430 - **Capacitor Motor**
Capacitor Motor: A single-phase induction motor with a main winding arranged for direct connection to the power source, and auxiliary winding connected in series with a capacitor. There are three types of capacitor motors: capacitor start, in which the capacitor phase is in the circuit only during starting (It has a high starting torque and is widely used typically up to 7-1/2 hp) , permanent-split capacitor, which has the same capacitor and capacitor phase in the circuit for both starting and running (High torque, low run curent); two-value capacitor motor, in which there are different values of capacitance for starting and running. for the

CAPACITOR START

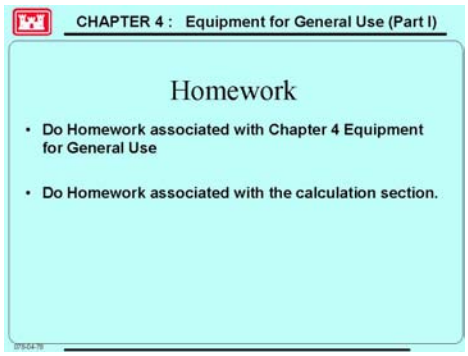
The capacitor start single phase motor is basically the same as the split phase start, except that it has a capacitor in series with the starting winding. The addition of the capacitor provides a more ideal phase relation and results in greater starting torque with much less power input. As in the case of the split phase motor, this type can be reversed at rest, but not while running unless special starting and reversing switches are used. When properly equipped for reversing while running, the motor is much more suitable for this service than the split phase start as it provides greater reversing ability at less watts input.



Slide 078-04-74:
Article 430 – **Synchronous Motor**
Synchronous Motor. This is a motor designed to run a specific speed. Two basic types: nonexcited and direct current excited. The DC excited type requires a DC source to excite the field. The DC current of the rotor field interacts with the stator AC current to produce torque required to turn the rotor at synchronus speed.



Slide 078-04-75:
Article 430 – **Induction Motors**
Induction Motors. Cage rotor is the most common. Usually referred to squirrel cage motors. The wound-rotor motor and three-phase motors that operate basically the same a squirrel cage motors. The only difference between the two is that the wound-rotor has two sets of leads extending from the controller and a bank of resistors to slip rings that are connected to the rotor. As the amount of resistance in the circuit varies, so does the speed of the motor. The greater the resistance in the rotor, the slower the rotor will run. The resistor banks may be separate from the motor or they may be incorporated in the controller.



Slide 078-04-76:
Homework is due tomorrow morning.